NOAA Data Report ERL GLERL-7

NORTHERN LAKE MICHIGAN CHEMICAL AND PHYSICAL CHARACTERISTICS DATA FOR 1970

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January 1980

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UNITED STATES DEPARTMENT OF COMMERCE
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NORTHERN LAKE MICHIGAN CHEMICAL AND PHYSICAL CHARACTERISTICS DATA FOR 1970*

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Water samples at standard depths, bottom sediment, and meteorological data were collected in Northern Lake Michigan at established stations in the course of 12 cruises during the 1970 open-water season. The sampling program and analytical methods are described. Chemical characteristics of the water and bottom sediment are listed by cruise for each station and sampling depth. Wind, wave, and sediment data are listed by cruise for each station. The statistical summaries showing lake-wide means, standard deviations, and sample sizes of selected variables are presented by depth for each cruise period.

1. INTRODUCTION

This basic data report presents data collected aboard the Research Vessel *Shenehon* by the Water Characteristics Branch of the Great Lakes Research Center, U.S. Army Corps of Engineers, Lake Survey District, between 23 May and 13 November 1970. During this period, on 3 October, the Great Lakes Research Center was transferred, along with other Lake Survey units, to the National Ocean Survey of the National Oceanic and Atmospheric Administration.

Data was collected systematically so that the lateral distribution of the chemical and physical characteristics of water in Lake Michigan, as well as their variations with respect to time, were measured and examined. The sampling program was designed to provide the basic data that, together with other available data, are necessary for defining relationships of significant water characteristics, determining the rate and extent of mixing of introduced contaminants, forecasting water quality, estimating the nature and magnitude of past events, and developing simulation models for use in management and development of the lake. Other agencies using the *Shenehon* for scientific studies during the season include the Federal Water Quality Administration, 4-13 August, for their water quality program, and the Great Lakes Foundation, 28 October, for a bathymetric survey of Little Traverse Bay. Also, the Shore Processes Project of the Lake Survey Center made internal wave measurements during the period 18-29 August (Great Lakes Research Center, 1970).

Interpretations of the data are not within the scope of this report and will be presented in subsequent publications. Meteorological conditions, as well as profiles of water temperature and transparency recorded at each station, are not included in this report.

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*GLERL Contribution No. 173.

2. METHODS

2.1 Sampling Program

Water characteristics, bottom sediment, and meteorological data were collected at 61 primary stations (Figure 1, Table 1). Sixty stations were sampled on a regular basis. Station 62 was sampled only once. Stations 61 and 72-76 were used to designate repeat samplings during the same cruise at one of the primary stations. Stations 63-71 and 77-80 were established as part of the Shore Processes Project for internal wave measurements between Frankfort and Holland, Mich. Twelve cruises were made during the survey season (Table 2). A cruise is defined as the time period starting when the *Shenehon* left the port at Mackinaw City, Mich., and ending upon the return to the same port. A full cruise normally required 10-14 days. Shipboard and laboratory determinations made during each cruise are summarized in Table 3.

The ship was navigated and stations were established by using a gyro compass, radar, a sextant, and visual fixes. Polystyrene floats were used to mark the deep-water stations and facilitate the return to the same location. Water sample depths in feet were determined by a meter wheel and converted to the nearest meter. The water depth to the bottom was determined by a Raytheon Precision Survey Fathometer, Model DE-723B, with a range of 0 to 250 in feet or fathoms and the depth presented as a graphic record on a calibrated paper chart.

Water samples were taken at multiple levels at each station in Fjarlie bottles. Samples at stations located in shallow water were sampled at the surface, mid-depth, and near bottom. In the upper 100 m, samples at stations located in deep water were taken at the surface and spaced 10-, 20-, or 25-m intervals. Below 100 m, the spacing was 50-to 100-m intervals, with the deepest sample near bottom. Bottom sediment samples were taken with a Shipek sampler.

Water temperatures were recorded at sampling depth to the nearest hundredth degree Celsius by protected reversing thermometers (±0.02° accuracy) attached to each Fjarlie bottle. The temperature of the water circulating through the sea chest, approximately 1.5 m below the surface, was recorded to the nearest tenth degree Celsius and printed with the meteorological data at 6-min intervals. Temperature profiles were recorded at each station to a maximum depth of 70 m with a Marine Advisors, Inc., Electronic Bathythermograph, Model 0-5a. The bathythermograph profiles were corrected by adding or subtracting the average difference between the reversing thermometer and bathythermograph temperatures.

Transparency profiles were made to a maximum depth of 70 m with a G. M. Mfg. and Instrument Corp. Deep-Water Turbidity Meter, Model 17-M-11, modified by the U.S. Lake Survey. Transparency was determined by relating light transmission along a 1-m path through the water to the

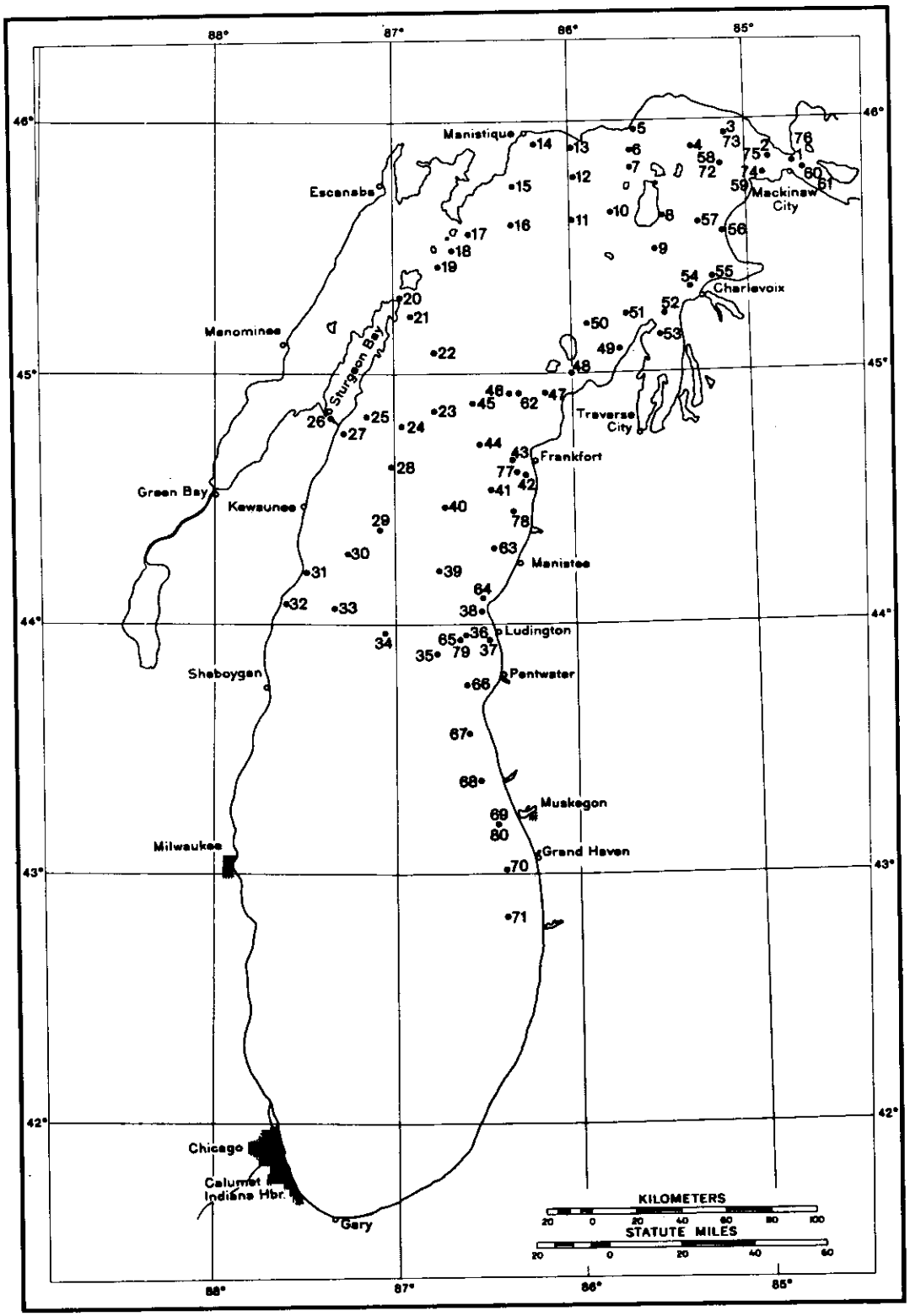

Figure 1. Station locations in Northern Lake Michigan during 1970.

Table 1. Station Locations in Northern Lake Michigan During 1970 (by Latitude and Longitude)

Station	Latitude	Longitude	Station	Latitude	Longitude
1	45.83°N	84.72°W	41	44.54°N	86.46°W
2	45.85°N	84.86°W	42	44.59°N	86.26°W
3	45.94°N	85.11°W	43	44.65°N	86.33°W
4	45.89°N	85.30°W	44	44.72°N	86.52°W
5	45.96°N	85.62°W	45	44.88°N	86.56°W
6	45.88°N	85.65°W	46	44.92°N	86.35°W
7	45.82°N	85.65°W	47	44.92°N	86.14°W
8	45.62°N	85.47°W	48	45.00°N	86.00°W
9	45.49°N	85.52°W	49	45.09°N	85.73°W
10	45.59°N	85.69°W	50	45.19°N	85.90°W
11	45.62°N	85.98°W	51	45.23°N	85.68°W
12	45.78°N	85.97°W	52	45.23°N	85.46°W
13	45.90°N	85.98°W	53	45.15°N	85.50°W
14	45.91°N	86.19°W	54	45.34°N	85.33°W
15	45.74°N	86.31°W	55	45.37°N	85.20°W
16	45.59°N	86.32°W	56	45.55°N	85.13°W
17	45.55°N	86.57°W	57	45.60°N	85.27°W
18	45.49°N	86.67°W	58	45.82°N	85.13°W
19	45.43°N	86.74°W	59	45.78°N	84.90°W
20	45.30°N	86.96°W	60	45.80°N	84.67°W
21	45.23°N	86.90°W	61	45.80°N	84.67°W
22	45.09°N	86.76°W	62	44.92°N	86.31°W
23	44.86°N	86.77°W	63	44.30°N	86.45°W
24	44.79°N	86.96°W	64	44.10°N	86.52°W
25	44.83°N	87.15°W	65	43.94°N	86.63°W
26	44.82°N	87.36°W	66	43.76°N	86.62°W
27	44.77°N	87.28°W	67	43.56°N	86.60°W
28	44.64°N	87.02°W	68	43.38°N	86.54°W
29	44.38°N	87.08°W	69	43.20°N	86.46°W
30	44.29°N	87.26°W	70	43.01°N	86.41°W
31	44.21°N	87.49°W	71	42.82°N	86.40°W
32	44.08°N	87.60°W	72	45.82°N	85.13°W
33	44.08°N	87.33°W	73	45.94°N	85.11°W
34	43.96°N	87.05°W	74	45.78°N	84.89°W
35	43.91°N	86.77°W	75	45.85°N	84.86°W
36	43.96°N	86.61°W	76	45.83°N	84.72°W
37	43.94°N	86.48°W	77	44.60°N	86.32°W
38	44.05°N	86.53°W	78	44.45°N	86.35°W
39	44.21°N	86.76°W	79	43.94°N	86.63°W
40	44.47°N	86.72°W	80	43.20°N	86.46°W

Table 2. Cruise Schedule

Cruise	Date
1	23 May-9 June
2	11 June-20 June
3	24 June-4 July
4	7 July-17 July
5	21 July-4 Aug.
6	4 Aug.-14 Aug.
7	15 Aug.-7 Sept.
8	9 Sept.-23 Sept.
9	26 Sept.-14 Oct.
10	15 Oct.-25 Oct.
11	27 Oct.-10 Nov.
12	11 Nov.-13 Nov. (partial cruise)

transmission along the same path through air, expressed as a percent. Color filters were not used.

Meteorological observations were recorded automatically at 0.1-hr intervals by a digital system employing solid state data gathering modules. Wind and wave observations were made while on station. The wave direction was not reported at all stations and in such cases the wind direction was used. Wave height observations were made with a damped staff-type gage or by estimating and periodically checking with the gage. The period is based on an average time of 10 successive waves.

2.2 Chemical Analyses

The methods used in the water analysis are those described in Standard Methods (American Public Health Association, 1965), Rainwater and Thatcher (1960), and Fishman and Skougstad (1965).

Water samples were analyzed immediately in the *Shenehon* laboratory for dissolved oxygen, specific conductance, chloride, phenolphthalein and total alkalinity, pH, Eh (oxidation-reduction potential), the pH and Eh of the interstitial water of the bottom sediment, and total coliforms.

Dissolved oxygen values were determined with a Beckman Dissolved Oxygen Analyzer, Model 777. After two separate tests were made on each sample, the highest partial pressure and the lowest sample temperature readings were used for calculating the dissolved oxygen. *In situ* temperature was recorded by the reversing thermometer at the sampling depth.

Table 3. Shipboard and Laboratory Measurements in Connection with Limnological Studies

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Shipboard Measurements

Meterological data (printout each 6 min)

- Wind speed (m/sec) (10 m above water)
- Wind direction (10 m above water)
- Barometric pressure (millibars) (3 m above water)
- Air temperature (°C) (10 m above water)
- Water temperature (1.5 m below water surface)
- Solar radiation (incident) (gram-calories per sq. cm, 10 m above water)
- Relative humidity (3 m above water)

On station

Water

- Water temperature (°C)
  - Reversing thermometers at sample depth
  - Electronic bathythermograph
  - Infrared thermometer for surface temperature
  - Air-water interface temperatures
- Transparency (relative to 100% in air)
- Secchi disc (m)
- pH
- Eh (volts)
- Total and phenolphthalein alkalinity (mg/l $CaCO_3$)
- Chloride (mg/l)
- Specific conductance (micromhos at 25°C)
- Dissolved oxygen (mg/l and pct. sat.)
- Coliform bacteria (membrance filter proc.)

Waves

- Height (m)
- Period (sec)
- Direction (nearest 10°)

Bottom sediment

- Description (physical)
- pH
- Eh
- Biochemical oxygen demand

Chemistry Laboratory

Dissolved ions (Beckman DU-2 Spectrophotometer)

Nitrate	(Brucine method, A.P.H.A.*, 1965)
Phosphate	(Ammonium molybdate method, U.S.G.S.**, 1965)
Sulfate	(Turbidimetric method, A.P.H.A.*, 1965)
Silica	(Molybdate blue method, U.S.G.S.**, 1960)
Magnesium	(Eriochrome black T method, U.S.G.S.**, 1960)
Calcium	(Flame photo tech, A.P.H.A.*, 1965)
Sodium	(Flame photo tech, A.P.H.A.*, 1965)
Potassium	(Flame photo tech, A.P.H.A.*, 1965)

Suspended sediment (mg/l)

Bottom sediment

- Percent solids
- Percent volitiles
- Oil and grease

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*American Public Health Association.
**U.S. Geological Survey.

Specific conductance was measured with an Industrial Instruments Conductivity Bridge, Model RC-16B2J. Two separate tests were made on each sample and the average expressed in micromhos at 25°C.

Chloride concentrations were determined by the argentometric method and titration of a 50-ml sample of lake water. The silver nitrate was standardized and the reagent blank value determined at the beginning of each day.

Phenolphthalein and total alkalinity values were determined by titrating 100-ml water samples with standard acid (H_2SO_4) to the end-points of pH 8.2 and 4.5, respectively. The end-points were determined with the pH meter and the results expressed in milligrams per liter of calcium carbonate.

Measurements of pH and Eh were made with a Beckman Zeromatic pH Meter, a glass pH electrode, calomel fiber junction reference electrode, and a platinum Eh electrode. As a means of avoiding contamination, the electrodes were rinsed in a sample of the lake water to be tested. Between tests, the electrodes were immersed in distilled water. Tests of the interstitial water of the bottom sediment were made by inserting the electrodes into the soft sample.

Unpreserved water samples in 500 ml plastic bottles were stored in a dark area below deck and transferred at the end of each cruise to the Great Lakes Research Center laboratory in Detroit for additional testing. Tests for nitrate and phosphate were made on unfiltered samples upon arrival at the laboratory. A Beckman DU-2 Spectrophotometer with flame attachment was used to analyze samples. Standard curves were constructed for each test and cruise. Sample concentrations were determined by computer application of the absorbancy values to a standard curve that was adjusted by paired test standards run after each set of 10 to 20 samples in order to compensate for any change or drift in the spectrophotometer response.

The bottom sediment was dried overnight at 100-105°C and the weight expressed as a percentage of the wet weight. Volatiles were determined by burning at 600°C for 1 hr and reported as a percentage of the dry solids. The concentration of hexane extractable hydrocarbons was determined by distillation and the weight reported as a percentage of the dry solids. The biological oxygen demand (BOD) tests were generally made on 1 gram of sediment incubated at 20°C.

3. PRECISION LIMITS

The degrees of precision of the various tests are summarized in Table 4. The estimated precision of the dissolved oxygen determination is based on the assumption that the oxygen partial pressure is accurate to 1 mm of mercury. The average difference in the two partial pressure readings for each sample was less than 1 mm of mercury. For specific conductance, the estimated precision is based on the assumption that the

Table 4. Measurement Precision

Variable	Units	Estimated precision	Average deviation*
Dissolved oxygen	percent	±1.0	
	mg/l	±0.1	
Specific conductance	micromhos at 25%C	±1.0	
Chloride	mg/l	±0.5	
Alkalinity	mg/l	±0.5	
Nitrate-N**	mg/l		±0.007
Phosphate-P**	mg/l		±0.0003
Sulfate	mg/l		±0.1
Silica	mg/l		±0.03
Calcium	mg/l		±0.1
Magnesium	mg/l		±0.7
Sodium	mg/l		±0.1
Potassium	mg/l		±0.05

*Average of the deviations of the test standards from the standard curve.
**Analysis of unfiltered samples of uncertain storage history.

average difference in the two conductance readings for each sample is less than 1 micromho. For both chloride and alkalinity, the estimated precision is based on the value of one drop (0.05 ml) of titrant and on the assumption that the accuracy was within ± one drop.

In order to determine the repeatability of the tests with the spectrophotometer, one must compare the pairs of test standards to the standard curve for that ion. Table 4 shows the average deviation of these standards from the best-fit curve.

From the end of a cruise to date of analysis, there was an interval ranging from 1 to 10 days for phosphate and from 2 to 11 days for nitrate. These samples were not preserved to fix the phosphorus and nitrogen, nor were they refrigerated. The 1970 phosphorus concentration values are considerably lower than those found during the 1973 and 1975 surveys (which were preserved with chloroform). Therefore, possible deterioration must be considered when using these values.

4. DATA PRESENTATION

The limnological data are summarized by cruise for each sampling depth at a given station (Appendix A). Nitrogen concentrations were calculated from nitrate by multiplying by a factor of 0.226. Phosphorus concentrations were calculated from phosphate by multiplying by a factor of 0.326.

The wind, wave, and bottom sediment data, with the exception of pH and Eh, are summarized by cruise and station (Appendix B).

In the statistical summary, lake-wide means, standard deviations, and sample sizes are presented by depth and cruise period for selected variables (Appendix C).

5. ACKNOWLEDGMENTS

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